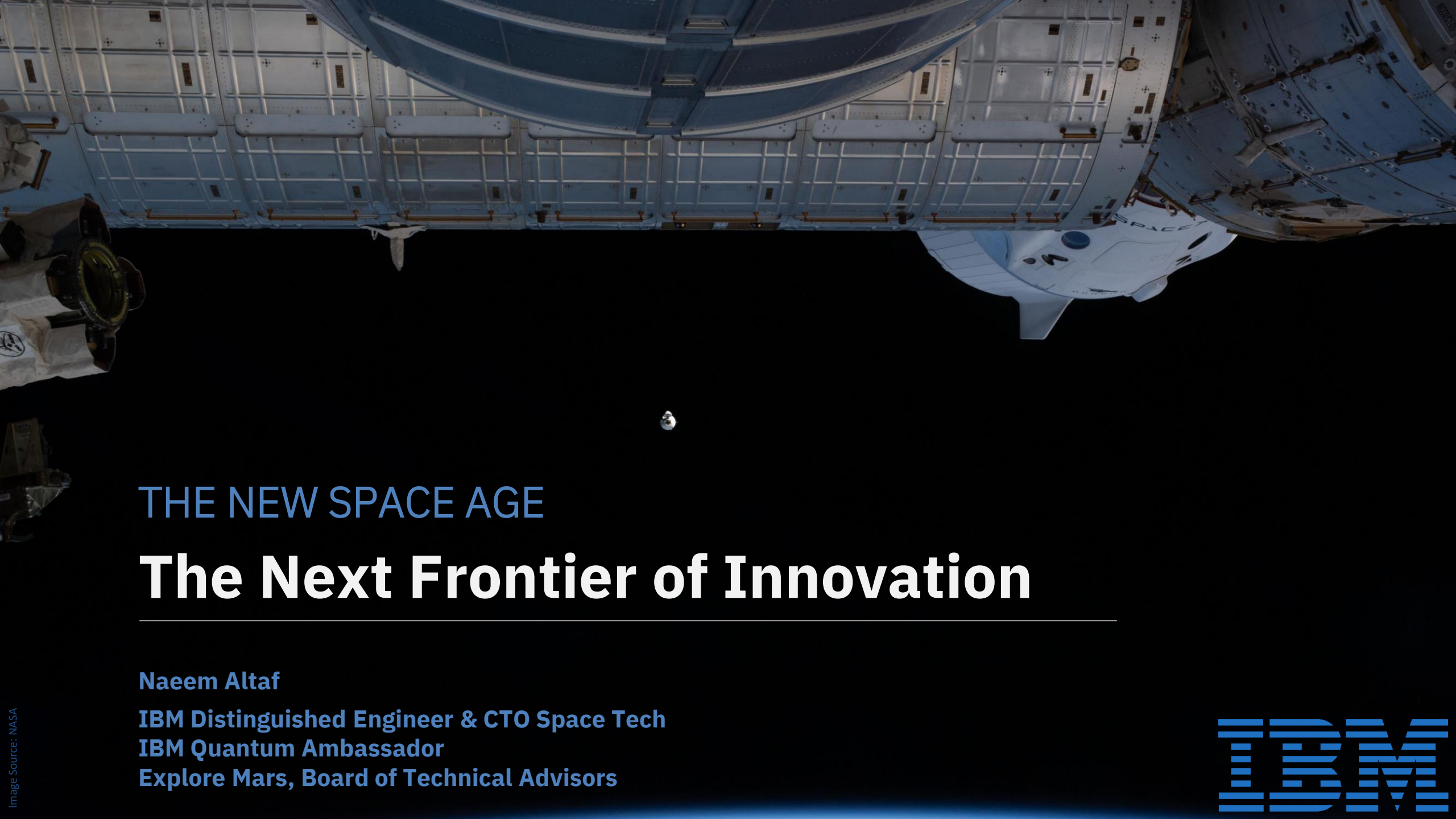


THE NEW SPACE AGE

The Next Frontier of Innovation

Naeem Altaf

IBM Distinguished Engineer & CTO Space Tech
IBM Quantum Ambassador
Explore Mars, Board of Technical Advisors

Image Source: NASA

IBM’s HISTORY AS

A PIONEER IN SPACE

> Without IBM and the systems they provided, we would not have landed on the Moon.

- Gene Kranz, NASA Flight Director

50 years ago, IBM created a mainframe that was critical in sending humans to the Moon

More than 4,000 IBMers worked tirelessly to help NASA put the first humans on the Moon (still regarded as one of the great engineering feats in history)

CURRENT SNAPSHOT OF THE

GLOBAL SPACE ECONOMY

Equity Investments (Q1 2021)

$4.5B

Source: Space Capital

FINANCIAL LANDSCAPE

GOLDMAN SACHS: Space industry would reach ***$1 trillion*** in the 2040s
MORGAN STANLEY: Global space industry may increase to ***$1.1 trillion*** by 2040
BANK OF AMERICA MERRILL LYNCH: Market growing to ***$2.7 trillion*** by 2040

SPACE TECH LANDSCAPE

NASA PUBLIC-PRIVATE PARTNERSHIPS:

- Return Humans to Moon (Artemis), Mars and Beyond, Opened ISS for commercial/private, Private companies to build landers, rovers

HUMAN SPACEFLIGHT:

- Astronauts and Private passengers (Space Tourism)

PRIVATE COMMERCIAL LAUNCHERS:

- SpaceX, Rocket Lab, Virgin Galactic, Blue Origin

MEGA CONSTELLATIONS:

- Starlink, Telesat, Kuiper, OneWeb, GW
  - SpaceX Starlink (12,000+ satellites)
  - Telesat (300 satellites)
  - Amazon Kuiper (3,236 satellites)
  - China Satellite Network Group (13,000 satellites)
  - OneWeb (2,000 satellites)

Edge Computing in Space International Space Station

DNA sequencing with the MinION device is allowing for the identification of microbes onboard the International Space Station (ISS). While DNA sequencing has become common onboard the ISS, data processing still requires the downlink of the data to Earth delaying the time to results.

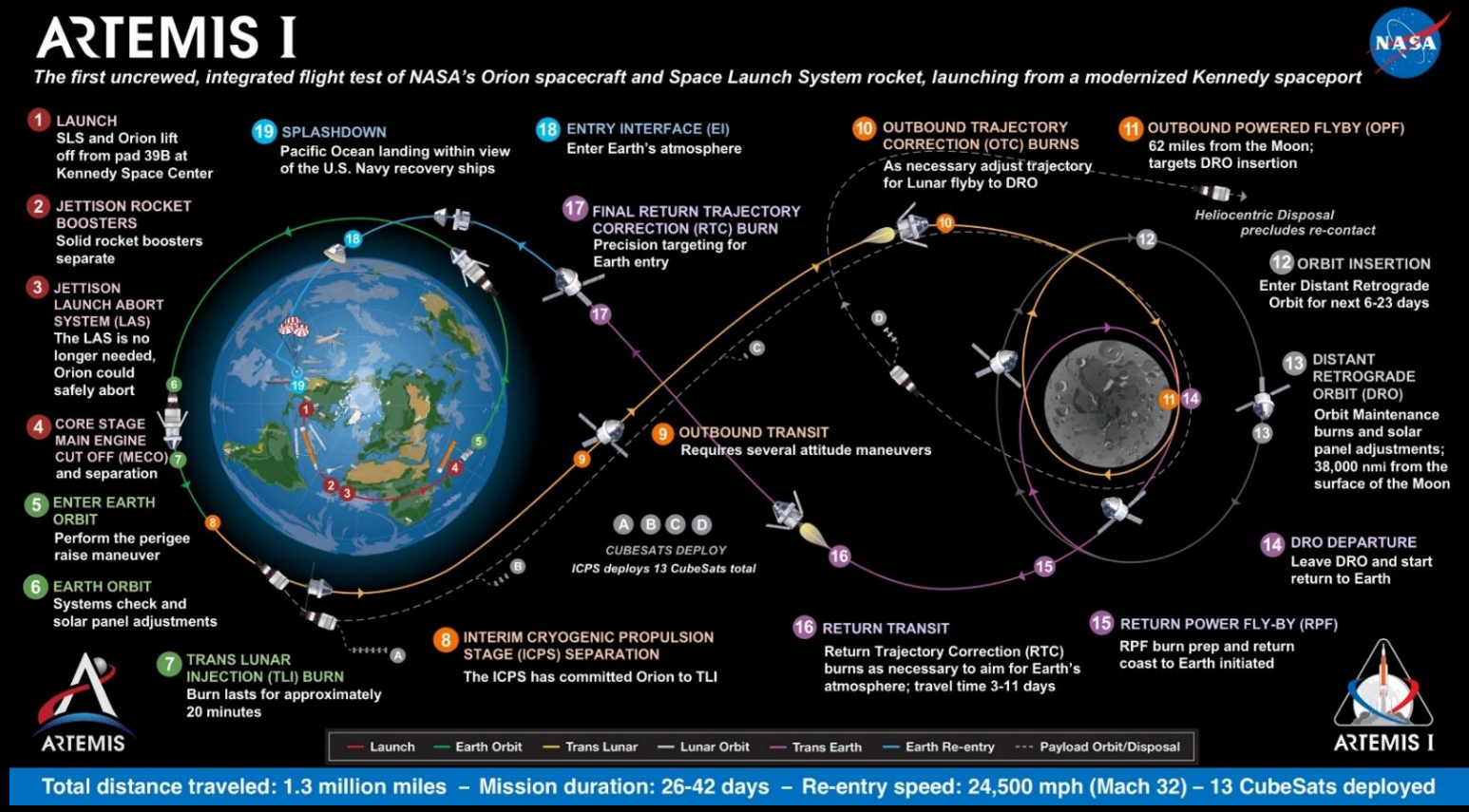
IBM developed the "Edge Computing in Space" solution. Eliminating the need to move the massive data being produced on the ISS by the DNA Sequencing project, by presenting containerized analytical code right where the data is being produced by leveraging the local compute to be available on ISS, reducing the time to less than a week to get results.

IBM's solution utilizes **Redhat CodeReady Containers, a single-node OpenShift cluster.** This solution connects back on the ground with **IBM Cloud** where researchers will develop, test, and make their code ready to be pushed to ISS.

A RETURN TO NASA's EXPLORATION ROOTS

THE ARTEMIS MISSIONS

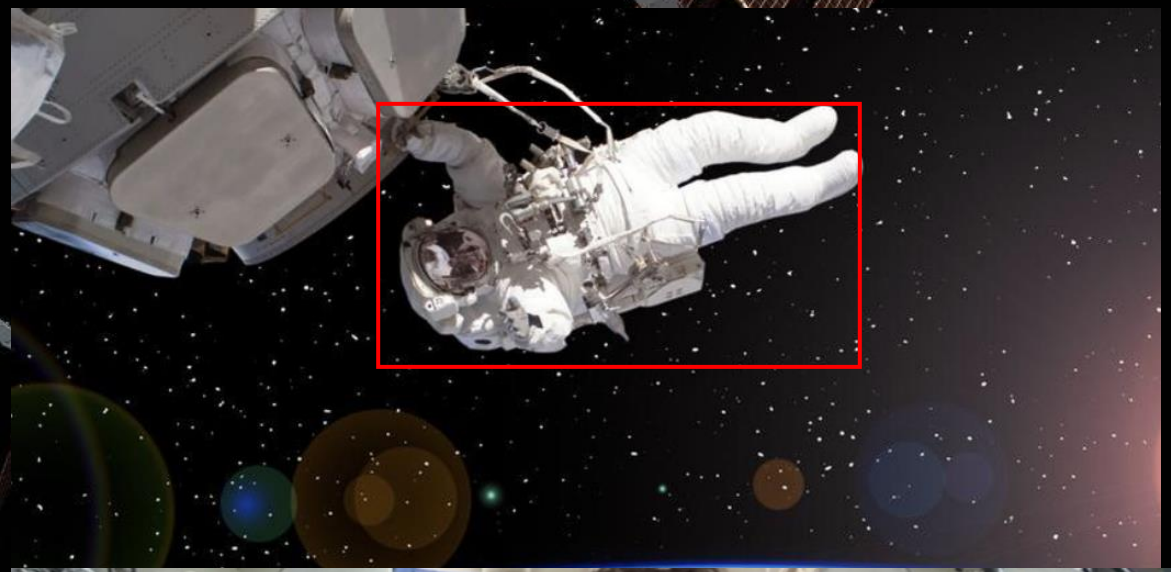
NASA will land the first woman and next man on the Moon by 2024, using innovative technologies to explore more of the lunar surface than ever before. We will collaborate with our commercial and international partners and establish sustainable exploration by the end of the decade. Then, we will use what we learn on and around the Moon to take the next giant leap – sending astronauts to Mars.

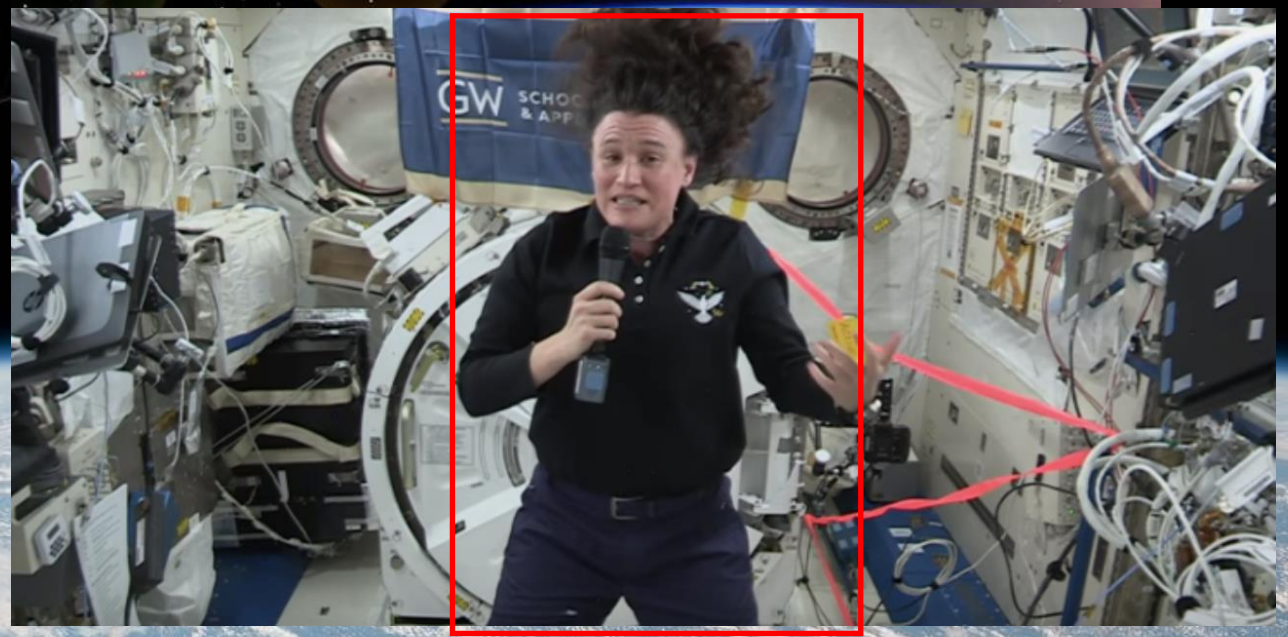


International Space Station (ISS)

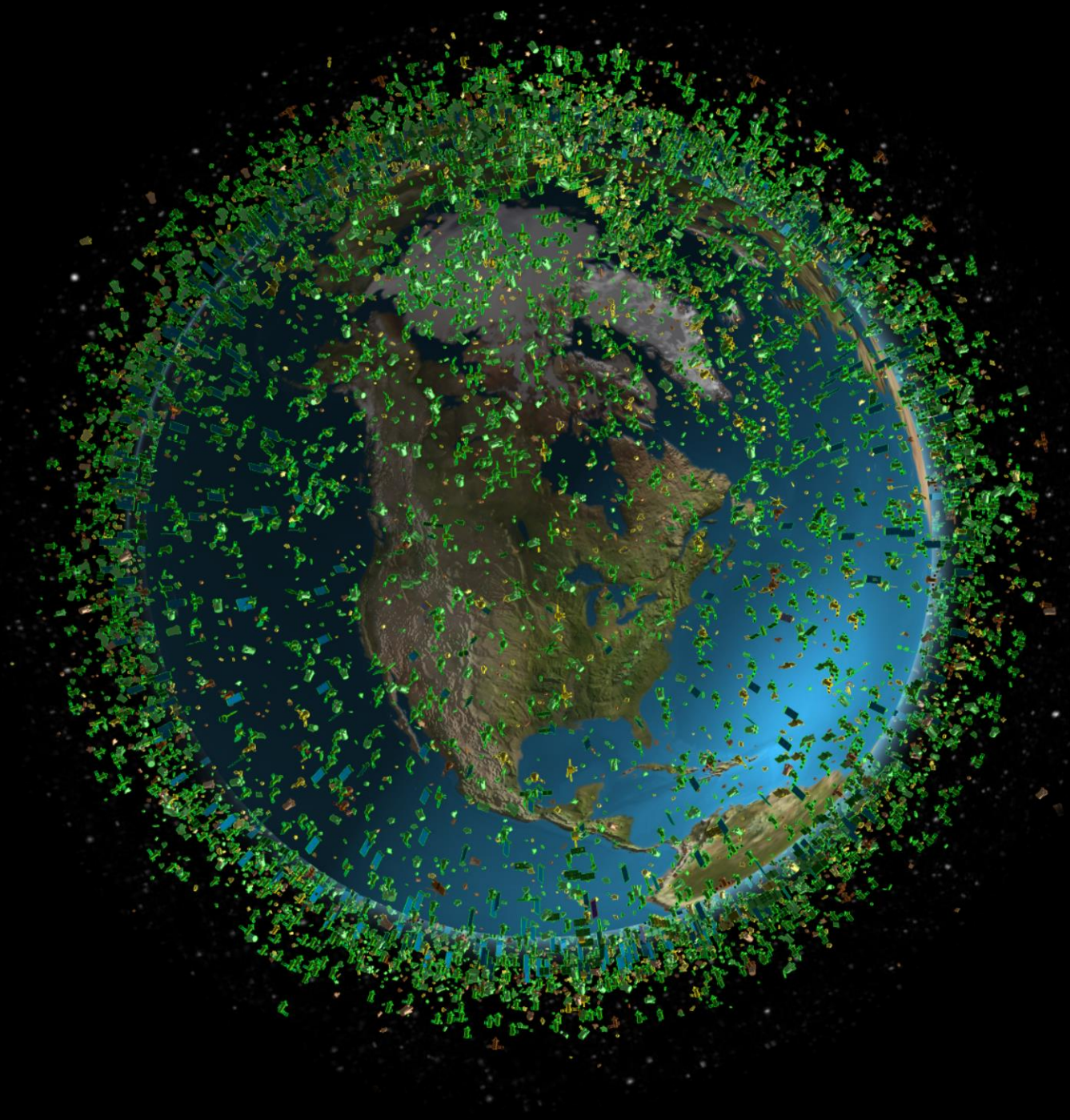
Object Recognition

- Trained deep learning models to identify individual crew members inside and outside of the ISS.
- Developed a computer vision motion detection pipeline to discern objects floating in zero gravity in a video stream.
- Deployed a custom dashboard to display results of real-time inferencing.
- Key Technologies Used:
  - Visual Insights
  - IBM Cloud





Activity in Lower Earth Orbit



- 8,950 - Satellites launched to-date
- 5,000 - Currently orbiting,
- 1,950 - Operational
- 34,000 objects greater than 10cm
- 130 million smaller than 1cm
- There are millions of pieces of debris in orbit that are too small to be tracked.

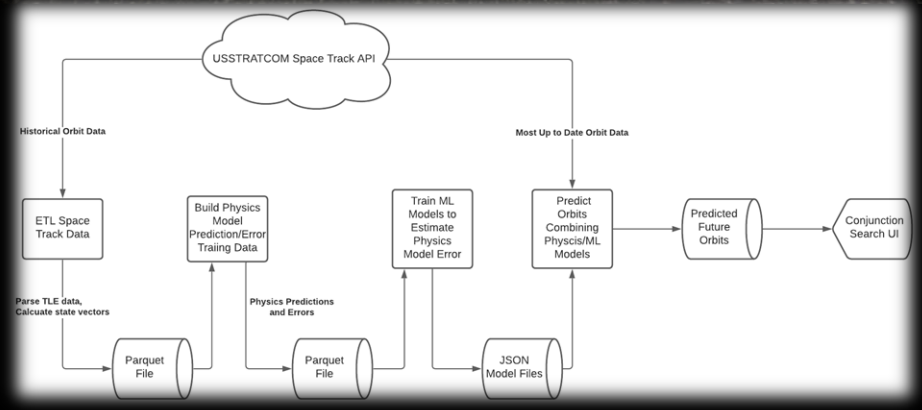
In LEO objects travel around 17,000 mph, altitude ranging from 250km to 1600km

Source: https://platform.leolabs.space/visualizations/leo
Source: https://astroscale.com/space-debris/

Space Situational Awareness

Space is becoming cluttered with objects launched by a growing number of commercial companies. Within the next few years, companies like (Starlink, Kuiper, Telesat, OneWeb) alone are planning to send more then 20,000+ satellites into space. We need better identification, tracking and sharing of information

- **Orbit Prediction:** The orbital prediction component combines physics and machine learning models to predict the future path of Resident Space Objects
- **Conjunction Search:** The conjunction search component combs through future orbit predictions to determine when and where two RSOs may come close to each other based on user provided search parameters
- **Light Pollution Prediction:** The light pollution service predicts the best window for deep space observations

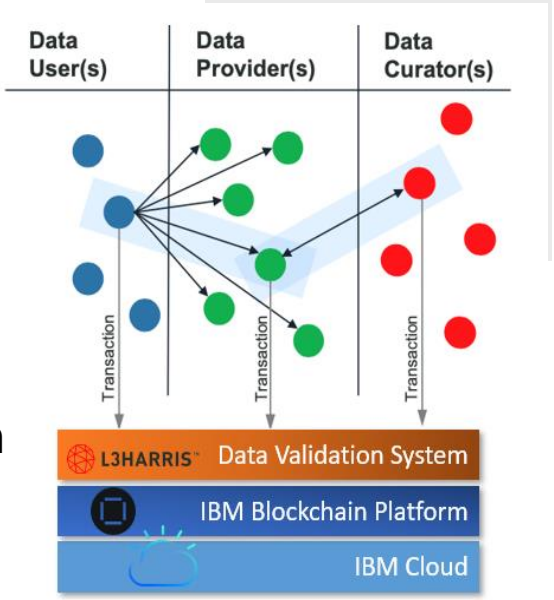


Open Source

GitHub https://github.com/IBM/spacetech-ssa

https://spaceorbits.net/

Space Traffic Management Data Exchange



Identifying and Tracking man-made objects in earth's lower earth orbit is a major challenge due to lack of cooperation among the agencies in data sharing. As more and more objects are being launched, it becomes critical to have a shared single source of truth to mitigate risk of collision which will be devastating. Working with L3Harris, a global aerospace and defense technology company towards a Data Exchange platform

1. Engage with L3Harris

March 2020

June 2020

2. Pilot and Demo complete
Client sees their idea in action

3. Interlock L3Harris with Blockchain Services team to discuss partnership

July 2020

August 2020

4. L3Harris used application in SACT-2.
Encouraging Stakeholder responses

4. Joint work presented at IAC (International Astronautical Congress) and published in journal

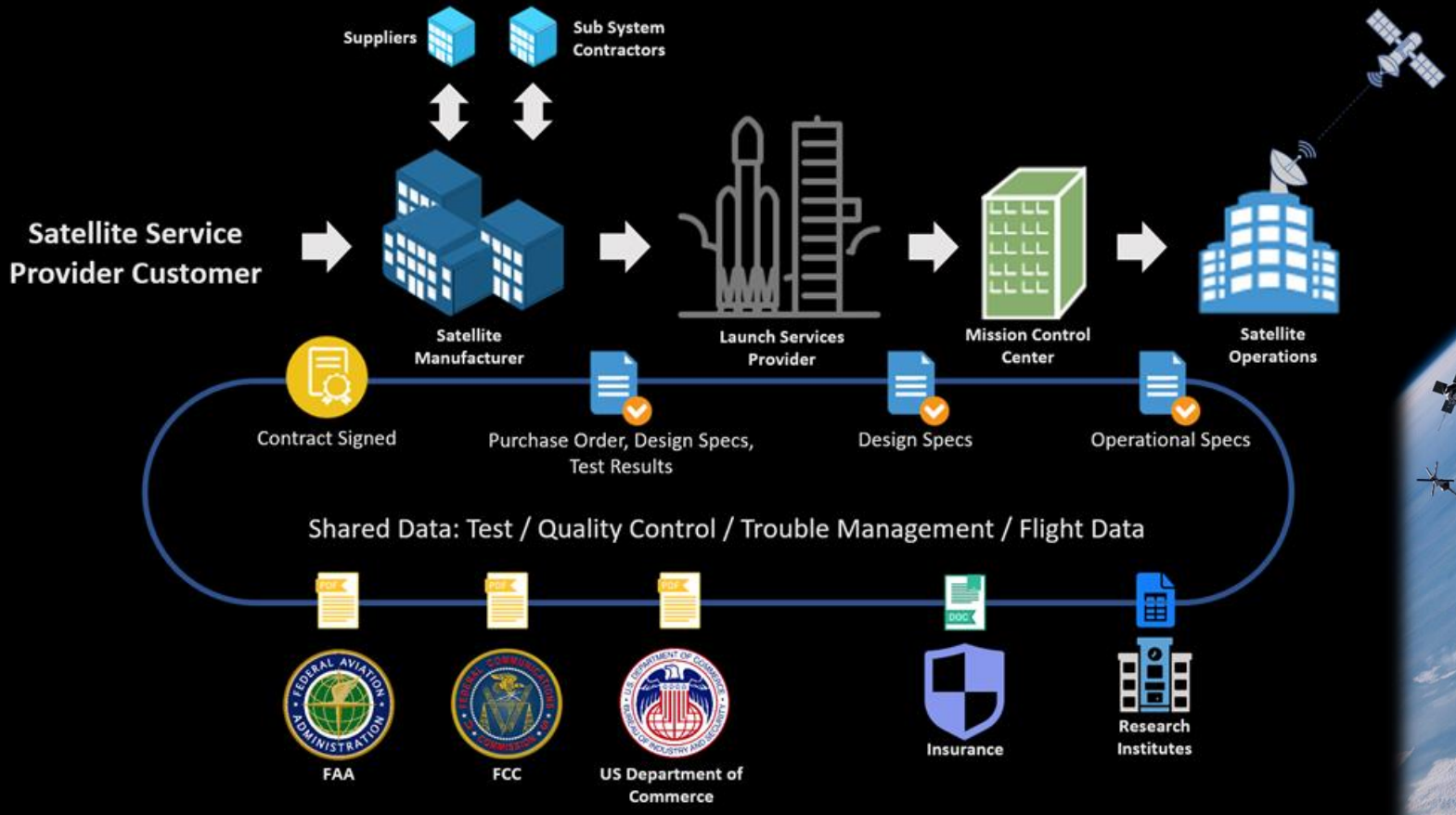
October 2020

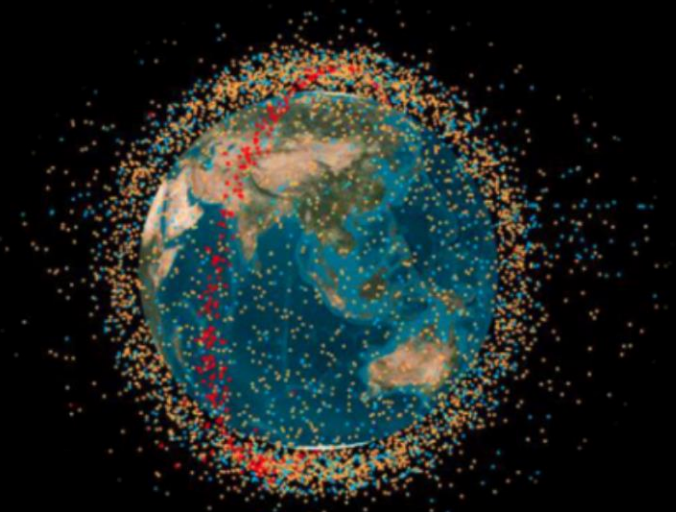
November 2020

5. Transitioned to Federal CTO team.
Continued demo in SACT-3 leading to funding $$$ (to be confirmed)

SACT: A three day-long exercise in a worldwide operational environment run by National Space Defense Center (NSDC) thrice a year.

Blockchain (Trust, Transparency & Provenance)



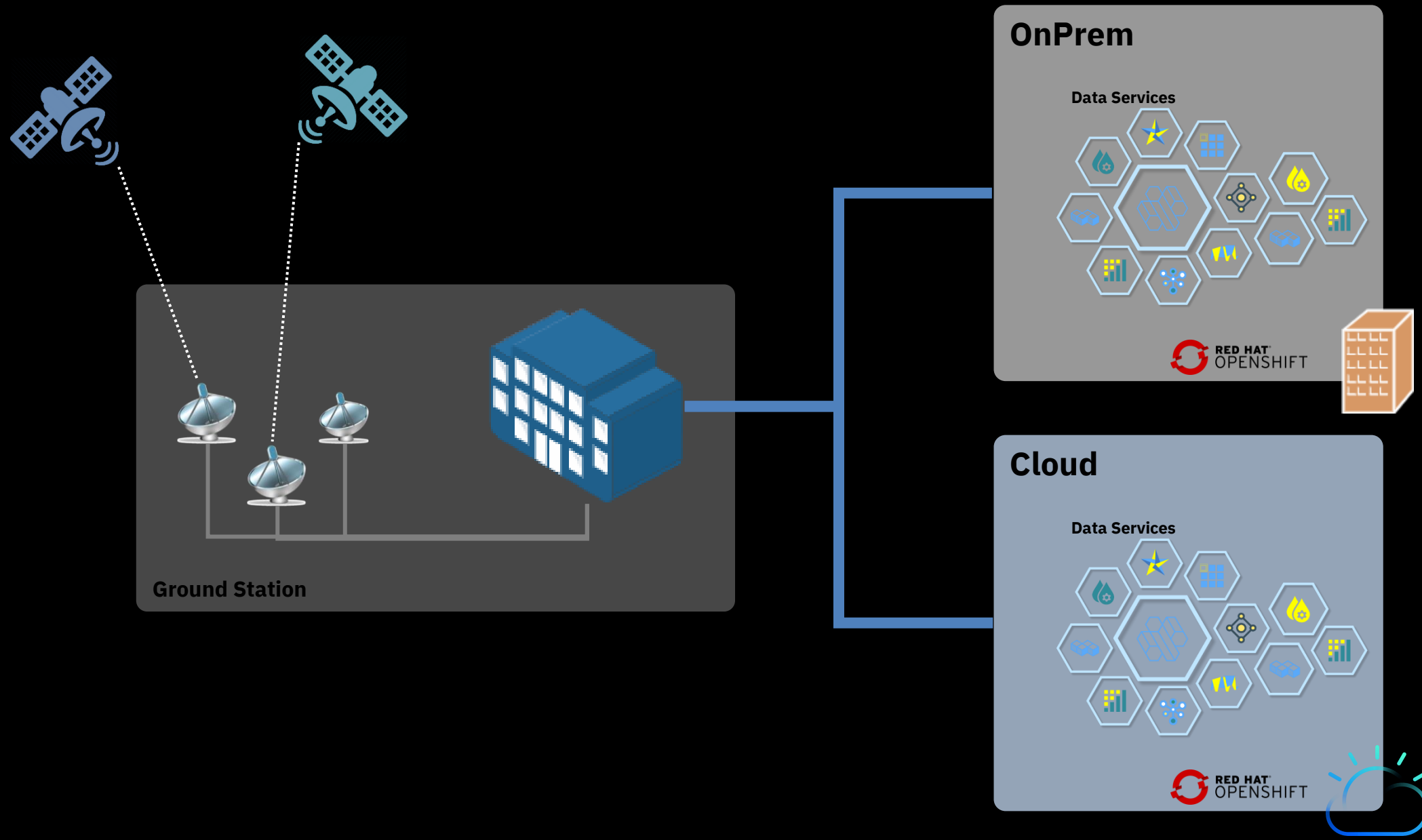


Space Traffic Management

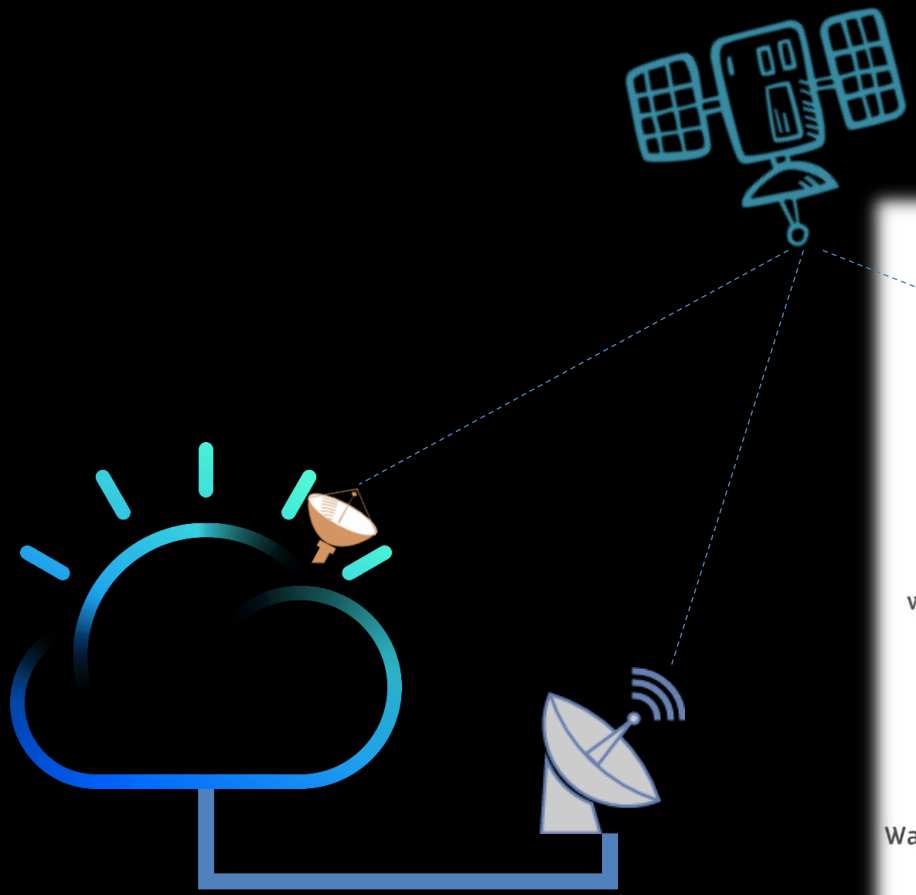
Satellite Manufacturing

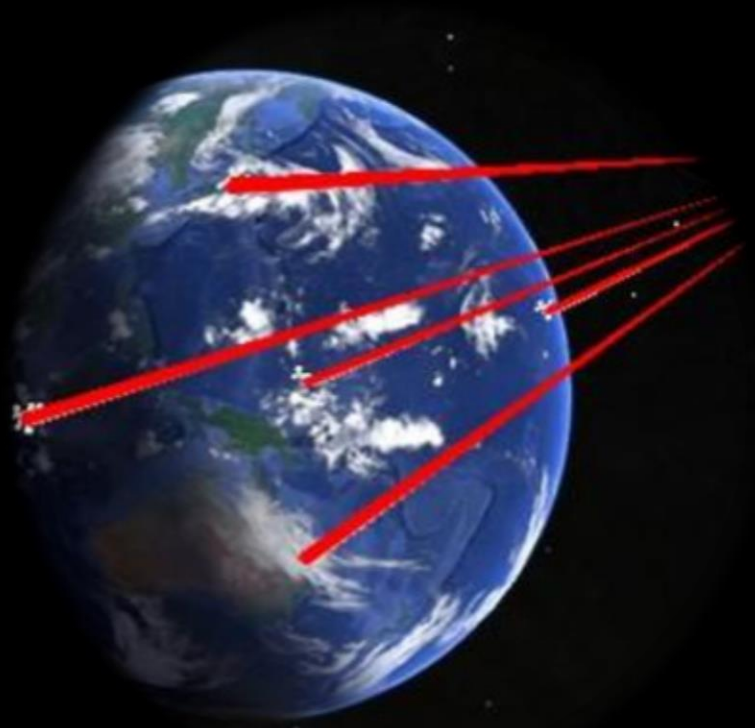
Space Cargo

Ground Stations & Hybrid Cloud

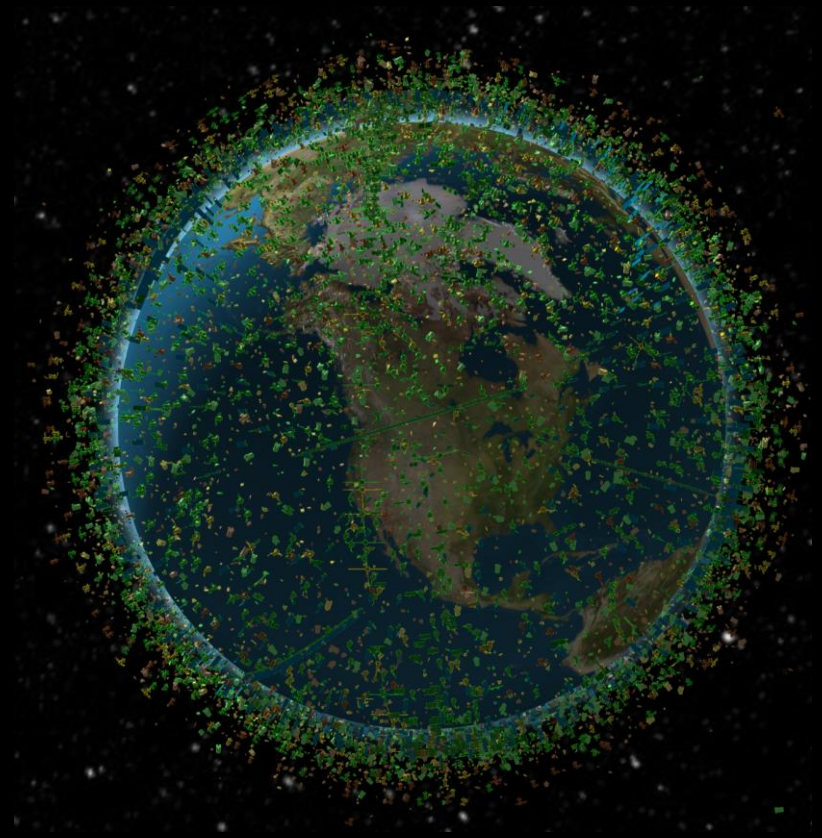


5G, Satellites & IOT

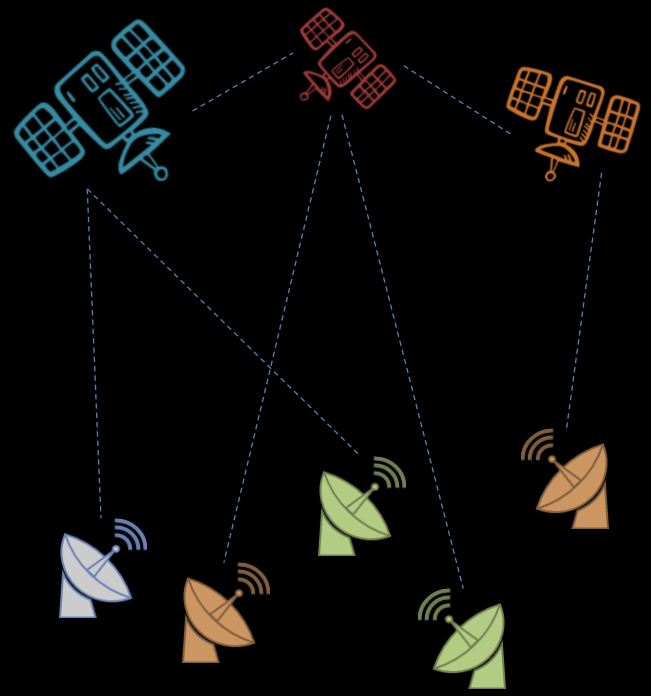




Quantum Communications



Collision Avoidance System in LEO



Satellite to Ground Stations Route Optimization

Quantum Computing for Space Tech

(Optimization & ML Use Cases)


Thank You
Naeem Altaf
naltaf@us.ibm.com